EXECUTIVE SUMMARY

On February 2, 2000, Dave Reardon and Ken Henderson of HDR Engineering conducted a “walk-through” energy evaluation of Vallejo Sanitation and Flood Control District’s wastewater treatment plant. In 1999, the plant paid $600,244 for 10,243,206 kWh of electricity. This results in an average of 5.76 ¢/kWh including demand charge and miscellaneous fees. During this time the plant treated approximately 4,526 Mgal (12.4 mgd), which gives a specific energy consumption of 2,263 kWh/Mgal. Typical secondary wastewater treatment plants consume 1,800 to 2,500 kWh/Mgal treated. A snapshot of energy for the plant is shown in Table 1-1.

Table 1-1. Vallejo FCSD Energy Snapshot for 1999.

Plant Flow	4,526 MGal
Average Daily Flow	12.4 mgd
Total Electricity Cost (5.7¢/kWh)	$600,244
Total Identified Savings for this Report	93,900 (15.6%)
Electricity Usage	
Purchased Electricity	10,243,206 kWh
Generated On-Site	Ø
Unit Energy Consumption	2,263 kWh/MGal (good considering high pumping energy)
Billing Demand Range	1,600 kW - 2,900 kW
Demand Component of Electrical Cost	20 percent

The information obtained from the energy distribution along with the data gathered during the site visit aided in identifying potential energy conservation measures (ECMs). The ECMs summarized in Table 1-1 are estimated to save approximately $206,000 annually and should be considered for implementation.

Table 1-1 Summary of ECMs

ECM	Energy Savings	Yearly Cost Savings	Possible PG&E Rebate	Estimated Capital Cost	Simple Payback (years)	Recommended
1. Change sheaves on sludge silo mixing pumps.	41 kW, 29,930 kWh/yr	$1,700	$2,693	$1,000	<1	YES
2. Control indoor lighting	0 kW, 87,600 kWh/yr	$5,000	$7,884	$10,000	2	YES
3. Lower No. 3 water pressure.	12 kW, 105,120 kWh/yr	$6,000	$9,460	$0	0	YES
4. Install an EMS system	140 – 200 kW, 0 kWh/yr	$16,900		$30,000	1.5	YES
5. Reduce air to basins at night	0 kW, 146,000 kWh/yr	$8,400	$13,140	$15,000	1.8	YES
6. Load shed on peak energy use	75 kW, 58,500 kWh/yr	$4,900	$5,265	$0	0	YES
7. Change discharge to Mare Island	127 kW, 893,500 kWh/yr	$51,000	$80,415	$150,000	3	YES
Total of Recommended ECMs		**$93,900**	**$118,857**	**$206,000**	**2.2**	

OBSERVATIONS & RECOMMENDATIONS

Observations

1. The plant is very well maintained and the solids processing operation is immaculate.

2. Unit energy consumption is 2,263 kWh/Mgal, which is typical for secondary treatment plants.

3. The plant has relatively low biosolids energy consumption but very high effluent pumping energy.

4. The plant has high biosolids production from lime stabilization and the additional loading of alum sludge from the water treatment plant.

5. The plant has elected to use PG&E's non-firm, interruptible E-20S rate schedule, which saves approximately $120,000 annually over firm service.

6. Plant staff have implemented numerous innovative measures on the biofilters. Installing mechanical drives, turning one tower off at night, and reversing air flow through the towers have each help to improve performance.

7. Demand charges account for approximately 20 percent of the electric bill.

8. Demand charges are heavily dependent on diurnal fluctuations in flow. The entire plant flow is pumped four times within the plant.

9. PG&E's proposed rate change should decrease the annual cost for power.

10. Effluent pumping represents over 20 percent of the plant energy consumption and a high percent of the demand charge. Any flow that can be diverted to the Mare Island outfall will result in significant energy savings. The savings could warrant modifications to the outfall to achieve the dilution necessary for discharge.

Recommendations

1. Implement recommended ECMs.

2. Apply for year 2000 rebate program with PG&E - 9¢/kWh for first year savings.

3. Establish an energy champion at the plant to monitor energy efficiency and implement energy conservation projects.

INTRODUCTION

This study is a joint effort between the Electric Power Research Institute (EPRI) and the California Energy Commission (CEC). Its purpose is to identify potential conservation measures that could reduce the plant's energy consumption or electrotechnologies that could improve the treatment process. HDR Engineering conducted the study as a consultant to both EPRI and the CEC.

PLANT DESCRIPTION

The wastewater plant treats an annual average flow of 12.4 mgd. The liquid treatment process includes a raw sewage pumping station, climbing screens, aerated grit chambers, primary sedimentation basins, biofilters, aeration basins, secondary clarifiers, and both UV and chlorine disinfection. The solids process includes solids blending tank, lime stabilization, gravity belt thickening, belt filter press dewatering, and landfill disposal. Figure 2-1 and 2-2 are schematics of the liquid and solids treatment processes.

SCOPE OF WORK

HDR Engineering performed a "walk-through" energy evaluation of Vallejo's wastewater treatment plant. On February 2, 2000, Ron Matheson gave Dave Reardon and Ken Henderson of HDR a tour of the facilities. Measures to reduce energy costs were identified from the information gathered during the site visit and are summarized in this report.

ACCURACY

This report is based on a "walk through" evaluation of Vallejo Sanitation and Flood Control District's wastewater treatment plant. It is a planning level document intended to identify energy conservation measures (ECMs) and electrotechnologies that could benefit plant operations. The recommended projects should be implemented only after conducting pre-design/design level analysis, which is beyond the scope of this report. The accuracy of all cost and savings estimates are ±25 percent. Construction cost estimates assume basic installations and are made for each idea individually. The total for engineering and construction services can vary depending on the combination of ideas selected for installation, the amount of instrumentation and control interfaces desired, the schedule of construction, and the level of bidding and construction services requested.

Figure 2-1 Liquid Process Schematic

Figure 2-2 Biosolids Process Schematic

ACKNOWLEDGEMENTS

HDR Engineering thanks the following people who were very helpful in the organization of the study and in conducting the field work:

Vallejo Sanitation and Flood Control District:

Ron Matheson

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Ray Ehrhard

California Energy Commission

Mike Hartley

Energy Consumption, Electric Rate Schedule, and PG&E Rebate Program

The total energy purchased in 1999 was determined from the electrical billing history. During this time the plant paid $600,244 for 10,243,206 kWh of electricity. This results in an average of 5.76 ¢/kWh including demand charges and miscellaneous fees.

The District purchases electrical power from Pacific Gas & Electric Company under rate schedule E-20P. The plant has elected to use PG&E's non-firm, interruptible schedule to decrease energy costs. PG&E has two primary charges for electrical power under this schedule. The first is for *demand*, which is the power supplied by the electric utility measured in kilowatts (kW). The second, *energy*, is the quantity of power used measured in kilowatt hours (kWh). Rate Schedule E-20P is a Time-of-Use (TOU) rate schedule that bills for both energy and demand based on the time of day it is used. The cost for power under the non-firm, E-20P rate schedule as of March 2000 is summarize below in Table 3-1.

Table 3-1 Rate Schedule E-20P Non-Firm Interruptible

	Period	Rate	Demand Charge
Summer	On-Peak	$0.04693/kWh	$4.30/kW
	Partial-Peak	$0.04689/kWh	$2.15/kW
	Off-Peak	$0.04505/kWh	$2.55/kW
Winter	Partial-Peak	$0.05492/kWh	$2.15/kW
	Off-Peak	$0.04587/kWh	$2.55/kW

Under the E-20P non-firm rate, 1 kW of power used continuously for a year costs an average of 5.7 ¢/kWh including demand charges. PG&E has applied to the Public Utility Commission to change the rate and structure of schedule E-20P. The proposed change would lower the cost per kWh and change the demand charge to a flat rate. Although the actual prices are not yet set, the net result for the District is expected to be a decrease in annual energy cost.

A graph of the plant's 1999 annual energy use was assembled for evaluation. As seen in Figure 3-1, electrical demand reflects influent flow during wet weather but deviates during dry weather. The cause of the wet weather spikes is primarily a result of increased pumping. The variations in the dry weather months can be the result of standby equipment being exercised or similar periodic events. Currently, most peaks occurred during the off-peak hours, which minimizes their impact on demand charges. However, if the proposed rate change is approved the demand charge will be billed at a flat rate. This will increase the cost of demand spikes. The ability to monitor demand in real-time could alleviate these occurrences and decrease demand charges.

An evaluation of the major electrical loads categorized by process indicates that effluent pumping uses approximately 30 percent on the total power. This is followed by the biofilters, aeration basins, and influent pumping station, which each use over 12 percent. Figure 3-2 shows the energy distribution within the treatment plant and the data is in Appendix A.

PG&E has a very attractive rebate program for 2000. Incentives of up to $1.5 million per customer and $400,000 per location are possible. Rebates are equivalent to the first year savings in kWh X 9¢. Contact your PG&E representative for more information.

Figure 3-1 1999 energy profile

Figure 3-2 Energy Distribution

ENERGY CONSERVATION MEASURES

The ECMs listed below were developed from information collected at the site visit and from evaluation of historical plant data. Unless otherwise noted, savings for the ECMs was determined using an average energy cost of 5.76 ¢/kWh, which includes demand charges. Calculations are in Appendix B.

ECM 1	Change sheaves on sludge silo mixing pumps.
ECM 2	Control indoor lighting
ECM 3	Lower No. 3 water pressure.
ECM 4	Install an EMS system
ECM 5	Reduce air to basins at night
ECM 6	Load shed on peak energy use
ECM 7	Change discharge to Mare Island

ECM 1 SUMMARY SHEET

CHANGE SHEAVES ON SLUDGE SILO MIXING PUMPS

Existing Conditions—

The mixing pumps operate approximately 2 hours/day. Actual head is approximately 20’. The design head is 55’, which results in a higher flow rate (~11,300 gpm) at an inefficient operating point (~55%).

Proposed Change—

Change the sheaves on the pump to reduce the speed and operating head (~580 rpm, 20’ TDH).

Benefit or Effect on Operations—

The pump will operate at a more efficient point on its curve. A smaller motor could also be installed.

Cost Analysis—

Demand Savings: 41 kW

Energy Savings: 29,930 kWh

Annual Operating Cost Savings: $4,800

Capital Cost for Changes: $1,000

Simple Payback: <1 year

Recommended: YES

ECM 2 SUMMARY SHEET

CONTROL INDOOR LIGHTING

Existing Conditions—
Lights were on in unoccupied rooms.

Proposed Change—
Initiate a light policy and/or install lighting control (timers, sensors, bank lighting) to minimize use of lighting in unoccupied areas.

Benefit or Effect on Operations—
Maintain sufficient lighting for safety.

Cost Analysis—
Demand Savings: 0 kW

Energy Savings: 87,600 kWh/yr

Annual Operating Cost Savings: $5,000

Capital Cost for Changes: $10,000

Simple Payback: 2 years

Recommended: YES

ECM 3 SUMMARY SHEET

LOWER NO. 3 WATER PRESSURE

Existing Conditions—
One pump operates at 90% speed and 90 psi. From pump curve: 90 psi (207 ft) , Q = 500 gpm.

Proposed Change—
Reduce pressure to 70 psi and review NPW system to reduce all unnecessary flows in plant. Operators can contact control center to boost pressure when needed for washdown during off-peak hours.

Benefit or Effect on Operations—
None anticipated.

Cost Analysis—
Demand Savings: 12 kW

Energy Savings: 105,120 kWh/yr

Annual Operating Cost Savings: $6,000

Capital Cost for Changes: $0

Simple Payback: immediate

Recommended: YES

ECM 4 SUMMARY SHEET

INSTALL AN EMS SYSTEM

Existing Conditions—

Electrical demand (kW) varies in the plant by approximately 150 to 200 kW. Demand charges are based on monthly peak demand.

Proposed Change—

Install an energy management system to monitor demand on a real-time basis. Provide set points and alarms to aid in identify the source(s) of spikes and adjust when able to control demand peaks.

Effect on Operations—

None anticipated. This increases awareness of the treatment process.

Cost Analysis—

Demand Savings: 140 to 200 kW

Energy Savings: none

Annual Operating Cost Savings: $16,900

Capital Cost for Changes: $30,000

Simple Payback: <1 year

Recommended: YES

ECM 5 SUMMARY SHEET

REDUCE AIR TO BASINS AT NIGHT

Existing Conditions—

The DO level in the aeration basins fluctuates between approximately 1 and 4 mg/l. The output of the blowers is set manually.

Proposed Change—

Control the DO in the aeration basins. A simple DO control strategy could be used to automate the speed selection on the 2-speed blowers based off of the signal from the existing DO probes.

Benefit or Effect on Operations—

None anticipated.

Cost Analysis—

Demand Savings:	0 kW
Energy Savings:	146,000 kWh
Annual Operating Cost Savings:	$8,400
Capital Cost for Changes:	$15,000
Simple Payback:	1.8 years
Recommended:	YES

ECM 6 SUMMARY SHEET

LOAD SHED ON PEAK ENERGY USE

Existing Conditions—

The electrical billing demand (kW) varies during the day and the year. The staff has no means to monitor or control demand costs.

Proposed Change—

Institute a control strategy to reduce electrical load and minimize on-peak billing demand. Postpone silo mixing, switch from UV to chlorine disinfection, and reduce NPW system pressure during on-peak hours (weekdays, noon to 6 PM). Using the primary clarifiers for storage could also reduce demand.

Benefit or Effect on Operations—

No adverse effects are anticipated. This could require momentary staff attention to reduce loads around the plant each day. Assume demand reduction savings only for 6 month annually.

Cost Analysis—

Demand Savings: 75 kW

Energy Savings: 58,500 kWh/yr

Annual Operating Cost Savings: $4,900

Capital Cost for Changes: $0

Simple Payback: immediate

Recommended: YES

ECM 7 SUMMARY SHEET

CHANGE DISCHARGE TO MARE ISLAND

Existing Conditions—

All flows below 30 mgd are pumped over a 75 foot static lift to Carquinez Straits. Mare island outfall has a 5 foot static head and has been modified to achieve the required dilution. Depth at Mare island is monitored by the plant.

Proposed Change—

Document depth to substantiate to Regional Board that dilution can be reliably met and petition to have primary point of discharge changed to Mare Island.

Benefit or Effect on Operations—

Since Mare Island pumping station was used to pump to Carquinez it should be refitted with new pumps to efficiently handle low head.

Cost Analysis—

Demand Savings: 127 kW

Energy Savings: 893,500 kWh/yr

Annual Operating Cost Savings: $51,000

Capital Cost for Changes: $150,000

Simple Payback: 3 years

Recommended: YES

PROCESS DISCUSSION

RAW SEWAGE PUMPING STATION

The plant has six raw sewage pumps rated at 100 hp each. The pumping station has a static lift of approximately 30 feet and a total TDH of approximately 35 feet. The pumps are each rated for 12 mgd and are equipped with variable speed drives. No energy conservation measures were identified for the raw sewage pumping station.

GRIT CHAMBERS AND BAR SCREENS

The plant has aerated grit chambers with 20 hp grit blowers. Two grit blowers were running on the day of the site visit but normally only one grit blower operates. No energy conservation measures were identified other than trying to use one grit blower rather than two.

PRIMARY SEDIMENTATION TANKS

Rectangular primary sedimentation basins are utilized for normal dry weather flow. Biosolids collected from the primary clarifiers are discharged to the solids processing facility. No energy conservation measures were identified for the primary clarifiers.

BIOFILTERS

Primary effluent is pumped through the biofilters in a one pass arrangement. Plant staff have modified the biofilter operation using several innovative techniques. To improve performance, staff has retrofitted the units with mechanical drives to allow very slow rotation and therefore improve flushing through the unit. Staff has also reversed the airflow through the unit such that the air flows downward through the media. This unusual technique allows the biofilter to scrub the air drawn downward, thus preventing the need for expensive odor control equipment. Biofilters are notorious for their odor-causing potential. However, the units at the Vallejo facility produce virtually no odors. Plant staff also conserves energy usage in the biofilters by turning off one of the filters during the night. One potential energy conservation measure was identified for the biofilters. It may be possible to reduce fan energy by reducing the air flow through the air circulation fans by approximately 20 percent. This could reduce energy usage in the fans by as much as 50 percent. The changes could be made by modifying the sheaves for the fan system. Because the fan motors are only one horsepower, the total savings could be less than 5 kW.

AERATION BASINS

The aeration basins use fine bubble diffusers and a short term contact. The only energy conservation measure for the aeration basins was to determine if it may be possible to use less air in the system during the night by controlling the air flow automatically. Using either timers or DO input to control the speed of the blowers is a low cost method to reduce the amount of air produced.

SECONDARY CLARIFIERS

Mixed liquor from the aeration basins is discharged to the secondary clarifiers. No energy conservation measures were identified for the secondary clarifiers.

DISINFECTION

The plant was using both medium pressure ultraviolet disinfection and sodium hypochlorite to comply with their previous discharge permit. The UV disinfection system treats all flows up to 30 mgd and appears to operate at about 5 kw per mgd. Flows over 30 mgd are treated with hypochlorite. During this study the plant received a new permit that follows a fecal coliform standard, which can be achieved with UV alone. Plant staff appear to be simplifying disinfection by minimizing hypochlorite and dechlorination chemicals. Although this will increase energy use we agree with their approach.

EFFLUENT PUMPING

The plant has four effluent pumps that lift wastewater to the Carquinez Strait. These pumps have 300 hp motors and are VFD controlled. Pumping to the Carquinez Strait requires considerable head. Head requirements are 90 to 120 feet depending on flow conditions. As a result, the effluent pumping station is the largest energy consumer in the plant. No energy conservation measures were identified for the effluent pumping station. However, energy for the effluent pumping can be reduced substantially by maximizing the amount of flow that is discharged at very low head or by gravity to the Mare Island outfall. Modifications have been made to this outfall that allow the plant to meet dilution requirements over ninety five percent of the time. Using this outflow more often would significantly reduce effluent pumping head and the operating cost of the pumping station.

NO. 3 WATER SYSTEM

The No. 3 water system appears to be operating with variable speed control at approximately 90 psi and a flow of approximately 500 gpm. This flow seems high for a plant of this size and an audit of the No. 3 water system should produce a significant reduction in the amount of flow required. We believe that the flow could be reduced to approximately 350 gpm. Also, the head for the system could be reduced from 90 psi to approximately 70 to 75 psi which would allow a significant reduction in power for the No. 3 water system.

SOLIDS PROCESSING

The plant does not have anaerobic digesters. Waste activated sludge and raw biosolids are discharged to the solids handling facility. Waste activated and primary biosolids are mixed with lime in silos and then dewatered on belt filter presses. The plant produces approximately 6,900 dry tons per year of solids including lime. Approximately 1000 tons of the 6,900 is lime sludge. The biggest energy consuming devices in the solids processing facility are the solids tank mixing pumps. WEMCO Hidrostal pumps mix the biosolids and the lime. They are rated at 7,000 gpm at 55 feet of head. These units operate only two hours per day. Their impact on total energy consumption is relatively small, but their effect on demand charges could be significant. We are not sure why the rated head for these pumps is 55 feet. Static lift is 0 feet and the total dynamic losses are probably less than 15 feet. The pumps are kept from operating far to the right on their curve by a throttling valve. It may be possible to reduce the energy for these pumps by reducing their speed and still being able to produce the desired flow rate. Energy and demand reductions by as much as two thirds may be possible. The solids processing facility also houses the high pressure air compressors. These are Atlas Copco units using rotary screws. The discharge pressure is approximately 92 psi. It may be possible to reduce energy consumption in this unit by installing a variable speed device that would allow more efficient operation rather than the loaded/unloaded operation now. The unit in the unloaded condition uses significant power even though no flow is discharged.

OBSERVATIONS & RECOMMENDATIONS

OBSERVATIONS

1. The plant is very well maintained and the solids processing is immaculate.
2. Unit energy consumption is 2,303 kWh/Mgal, which is typical for secondary treatment plants.
3. The plant has relatively low biosolids energy consumption but very high effluent pumping energy.
4. The plant has high biosolids production from lime stabilization and the additional oading of alum sludge from the water treatment plant.
5. The plant has elected to use PG&E's non-firm, interruptible E-20S rate schedule, which has saves approximately $120,000 annually over firm service.
6. Plant staff have implemented numerous innovative measures on the biofilters.. Installing mechanical drives, turning one tower off at night, and reversing air flow through the towers have each help to improve performance.
7. Demand charges account for approximately 20 percent of the electric bill.
8. Demand charges are heavily dependent on diurnal fluctuations in flow. The entire plant flow is pumped four times within the plant.
9. PG&E's proposed rate change should decrease the annual cost for power.
10. Effluent pumping represents over 20 percent of the plant energy consumption and a high percent of the demand charge. Any flow that can be diverted to the Mare Island outfall will result in significant energy savings. The savings could warrant modifications to the outfall to achieve the dilution necessary for discharge.

RECOMMENDATIONS

1. Implement recommended ECMs.
2. Apply for year 2000 rebate program with PG&E - 9¢/kWh for first year savings.
3. Establish an energy champion at the plant to monitor energy efficiency and implement energy conservation projects.

SECTION 1 -

EXECUTIVE SUMMARY 1

Observations & Recommendations 2
Observations 2
Recommendations 3

INTRODUCTION 4

Plant Description 4
Scope Of Work 4
Accuracy 4
Acknowledgements 7

ENERGY CONSUMPTION, ELECTRIC RATE SCHEDULE, AND PG&E REBATE PROGRAM 8

ENERGY CONSERVATION MEASURES 12

Change Sheaves on Sludge Silo Mixing Pumps 13
Control Indoor Lighting 14
Lower No. 3 Water Pressure 15
Install an EMS System 16
Reduce Air to Basins at Night 17
Load Shed on Peak Energy Use 18
Change Discharge to Mare Island 19

PROCESS DISCUSSION 20

Raw Sewage Pumping Station 20
Grit Chambers and Bar Screens 20
Primary Sedimentation Tanks 20
Biofilters 20
Aeration basins 21
Secondary Clarifiers 21
Disinfection 21
Effluent Pumping 21
No. 3 Water System 22
Solids Processing 22

OBSERVATIONS & RECOMMENDATIONS 23

Observations 23
Recommendations 23
List of Tables ii

List of Figures .... *ii*
Appendices.......... *ii*

List of Tables

Table 1-1 Summary of ECMs

List of Figures

Figure 2-1 Liquid Process Schematic
Figure 2-2 Simplified Biosolids Process Schematic
Figure 3-1 VS&FCD WWTP 1999 Energy Profile
Figure 3-2 VS&FCD WWTP Energy Distribution

Appendices

A Energy Distribution Data
B ECM Calculations